International Journal for Research Technology and Seminar
ISSN: 2347-6117 (Print) | ISSN: 3048-703X (Online)
International | Peer-reviewed | Refereed | Indexed Journal
Volume 28 | Issue 03 | Jan-Jun 2025

The Effects of Adding Reclaimed Asphalt Pavement (Rap) and Cement in Granular Base and Sub-Base Material

[1]Naman Rajput*, [2]Prof. R.K. Yadav

[1]M.E. (Student), [2]Professor

Department of Civil Engineering, Jabalpur Engineering College, Jabalpur (M.P.), India

Email ID: namanrajput2908@gmail.com

Accepted: 02.03.2025 **Published**: 08.03.2025

Keywords: RAP, GSB, Modified proctor test, MORTH.

Abstract

Reclaimed asphalt pavement (RAP) is removed using a milling machine that grinds the asphalt into small pieces and is a useful alternative to virgin materials as it reduces the use of virgin aggregate. The base course is a layer that comes below the surface layer of an asphalt pavement and consists of gravel material with lower specifications than the surface layer. Recycled asphalt pavement (RAP) is increasingly being used as the base material for highway construction as a sustainable solution. Due to the existence of asphalt, 100% RAP usually has low strength and high potential for creep and permanent deformations. RAP can be mixed with virgin aggregate, stabilized by cement to increase its strength and reduce its creep and permanent deformations. A good road network is the key to the rapid development of a country's economy. Gradually increase the percentage of cement in the mix (2, 4 and 6%) as shown in Tables 4 to 6 and it satisfies all the values of Tables 4 to 6 for Requirement for WMM- grading (table 400-II) of MORTH revision 4.

Paper Identification

*Corresponding Author

1. INTRODUCTION

A large amount of reclaimed asphalt pavement (RAP) material is produced during the maintenance and construction of highways. A portion of it can be used in new hot mix asphalt concrete and the rest is available for other uses. If these materials can be reused in the base and sub-base of roads, it will reduce environmental impact, reduce waste flow and also reduce transportation costs associated with road maintenance and construction activities.

The properties of RAP materials can be improved by mixing aggregates and adding chemical stabilizers. There has been a gradual increase in construction and demolition waste in recent years. This has resulted in waste disposal problems due to lack of available landfills. Reuse of these materials after proper recycling can be the perfect solution for this.

2. LITERATURE REVIEW

C. Rajesh Kumar et. al, (2020), Stabilization of soil to achieve the required engineering properties can be done by mechanical or chemical stabilization. Most of these methods are relatively expensive to implement in practice and the best approach is to use locally available materials. The present paper reports the stabilization of black cotton soil and loamy soil with varying percentages of reclaimed asphalt pavement (RAP) and waste crushed glass (WCG). **Sujeet Kumar Pradhan et. al, (2021)** Currently, the depletion of natural resources has significantly impacted the construction industry. The demand for fresh aggregates is becoming very high due to the increase in the construction of pavements and to meet the requirement of aggregates, which is a major concern.

Banafamu Andrew et. al, (2022) Despite the use of asphalt materials in other activities, a high percentage of it is poorly handled in Uganda. To this end, the aim of the present study was to investigate the mechanical performance of reclaimed asphalt pavement (RAP) with steel fibers in concrete and the variation of mechanical behavior with respect to different curing times with optimal RAP aggregate-substitute ratios. **Kavitha Karthikeyan et. al, (2023)** Over the past decade, there has been a growing interest in assessing the possibility of recycling materials from the construction sector. The growing interest in recycling materials is due to environmental benefits such as conserving existing pristine natural resources and reducing the total amount of materials that end up in landfills. **Danilo Lima (2023) et. al,** This study addresses unused recycled asphalt pavement (RAP) incorporated in sedimentary soil from the Guabirotuba Formation in Curitiba, Southern Brazil. Different percentages of RAP ranging from 0% to 80% by weight were mixed with pure soil with and without pozzolanic Portland cement.

Waseem Nazir et. al, (2021) Compaction characteristics have been observed between the standard Proctor and modified Proctor tests. The results show that the maximum dry unit weight values for both tests are similar, yet the optimum moisture content properties differ slightly. **Paul J. Cosentino et. al, (2016),** Reclaimed asphalt pavement (RAP) is a byproduct of road renovation. A limited amount of RAP can be recycled into new hot-mix asphalt; the rest is stockpiled. Some states allow RAP-aggregate mixtures to be used as base course material. Due to RAP's low strength and sensitivity to creep deformation, the Florida Department of Transportation (DOT) excludes using RAP as a pavement base course for high-traffic areas.

Ahmed Mahmood A. et. al, (2025) Reclaimed asphalt pavement (RAP) is produced in significant quantities. Nevertheless, the use of RAP is limited due to the absence of laboratory and field performance data. This research addresses laboratory and field tests to evaluate the use of RAP and various optimized mixtures in constructions such as road-bed layers and replacement layers.

Jirayut Suebsuk et. al, (2014) The article attempts to present the effect of reclaimed asphalt pavement (RAP) content on the compaction behavior and unconfined compressive strength of cement treated soil-RAP mixture. Laboratory compaction and unconfined compression tests were conducted on cement treated soil-RAP mixture with different RAP and cement contents. **Farag Khodary (2021)** Reclaimed asphalt pavement (RAP) is

International Journal for Research Technology and Seminar
ISSN: 2347-6117 (Print) | ISSN: 3048-703X (Online)
International | Peer-reviewed | Refereed | Indexed Journal
Volume 28 | Issue 03 | Jan-Jun 2025

removed using a milling machine that grinds the asphalt into small pieces and is a useful alternative to virgin material as it reduces the use of virgin aggregate. The base course is a layer that comes below the surface layer of asphalt pavement and consists of gravel material with lower specifications than the surface layer.

3. MATERIALS AND METHODS

3.1 Reclaimed asphalt pavement (RAP)

The materials that are generally obtained during the removal and reuse of existing asphalt layer pavements are known as RAP. At sites, RAP can be used immediately but generally, RAP is stored as stockpiles. RAP consists of well-graded aggregates and an aged bitumen content that can be used to replace a greater proportion of virgin aggregates and binder in new bituminous mixes. This reduces the initial cost of construction and solves the problem of waste disposal. It was found that the crush, impact and abrasion values of RAP aggregates are higher than natural aggregates.

Table 1 Physical properties of RAP

SL. No.	Tests	RAP Aggregate
1.	Crushing Value	23.53%
2.	Impact Value	16.26%
3.	Combined Flakiness and Elongation Index	26.8%
4.	Water Absorption	0.55%
5.	Specific Gravity	2.71

Figure 1. RAP Material

Figure 2. RAP Material (Filtration Process)

3.2 Natural aggregates (NA)

Natural aggregates and stone powder are the primary components of GSB mixture. The material used for the preparation of GSB should be of proper gradation, clean, and not rounded to withstand heavy traffic loads. From various researches, it was observed that there is a difference in the strength of RAP material.

Table 2 Physical properties of Natural aggregates

SL. No.	Tests	Natural aggregates
1.	Crushing Value	21.54%
2.	Impact Value	19.76%
3.	Combined Flakiness and Elongation Index	24.1%
4.	Water Absorption	1.55%
5.	Specific Gravity	2.84

3.3 Granular mix design

Using trial and error method several sizes of materials are mixed to meet the specified requirements for the particular GSB gradation. Sieve analysis should be done for each size of aggregate (20 mm, 10 mm, stone dust) and RAP to be used in the mix and calculate the final aggregate proportion in the mix to be designed.

4. RESULTS AND DISCUSSIONS

Table 3 Tests for Aggregates with IS codes

Property of Aggregate	Type of Test	Test Method
Crushing strength	Crushing test	IS:2386(part 4)
Hardness	Los Angeles abrasion test	IS:2386(Part5)
Toughness	Aggregate impact test	IS:2386(Part4)
Shape factors	Shape test	IS:2386(Part1)
Specific gravity and porosity	Specific gravity test and water Absorption test	IS:2386(Part3)

MORTH Gradation

Table 4 Details of composite WMM with use of RAP and cement (2%)

IS Sieve size (mm)	Material				Percent					Requirement for WMM-grading (table 400-II) of MORTH revision 4
	40 mm down	RAP	Stone dust	CE	30% 40mm down	60% RAP	8% Stone dust	CE 2%	Total	
53	100	100	100	100	30	60	8	2	100	100
45	100	100	100	100	30	60	8	2	100	95-100
22.4	28	94	100	100	8.4	56.4	8	2	74.8	60-80
11.2	0	72	100	100	0	43.2	8	2	53.2	40-60
4.75	0	40	98	100	0	24	7.84	2	33.84	25-40

2.36	0	24	76	100	0	14.4	6.04	2	22.44	15-30
0.6	0	12	38	100	0	7.2	3.04	2	12.24	8-22
0.075	0	2	10	100	0	1.2	0.8	2	4	<10

Table 5 Details of composite WMM with use of RAP and cement (4%)

IS Sieve size (mm)	Material				Percent					Requirement for WMM-grading (table 400-II) of MORTH revision 4
	40 mm down	RAP	Stone dust	CE	44% 40mm down	40% RAP	12% Stone dust	CE 4%	Total	
53	100	100	100	100	44	40	12	4	100	100
45	100	100	100	100	44	40	12	4	100	95-100
22.4	28	94	100	100	12.32	37.6	12	4	65.92	60-80
11.2	0	72	100	100	0	28.8	12	4	44.8	40-60
4.75	0	40	98	100	0	16	11.76	4	31.76	25-40
2.36	0	24	76	100	0	9.6	9.12	4	22.72	15-30
0.6	0	12	38	100	0	4.8	4.56	4	13.36	8-22
0.075	0	2	10	100	0	0.8	1.2	4	6	<10

Table 6 Details of composite WMM with use of RAP and cement (6%)

IS Sieve size (mm)	Material				Percent					Requirement for WMM-grading (table 400-II) of MORTH
	40 mm down	RAP	Stone dust	CE	53% 40mm down	25% RAP	16% Stone dust	CE 6%	Total	

										revision 4
53	100	100	100	100	53	25	16	6	100	100
45	100	100	100	100	53	25	16	6	100	95-100
22.4	28	94	100	100	14.84	23.5	16	6	60.34	60-80
11.2	0	72	100	100	0	18	16	6	40	40-60
4.75	0	40	98	100	0	10	15.68	6	31.68	25-40
2.36	0	24	76	100	0	6	12.16	6	24.16	15-30
0.6	0	12	38	100	0	3	6.08	6	15.08	8-22
0.075	0	2	10	100	0	1	1.6	6	8.6	<10

Compression Testing

To obtain gains in compressive strength characteristics, six cube specimens of size 150 mm × 150 mm × 150 mm were prepared from the mixture. The test cubes were cured under moist conditions for 7 days and 28 days. The prepared cube specimens were tested under compression testing machine.

Figure 3. Compression Testing Machine

International Journal for Research Technology and Seminar
ISSN: 2347-6117 (Print) | ISSN: 3048-703X (Online)
International | Peer-reviewed | Refereed | Indexed Journal
Volume 28 | Issue 03 | Jan-Jun 2025

Table 7 Determination of Cube Strength after 7 days

Sample No.	Samples	Cube Size (mm)	Maximum Load at Failure (kN)	UCS (MPa) 7 Days
1.	60% RAP + 30% NA+ 2% CE + 8% SD	150 mm X 150 mm X 150 mm	60	2.84
2.	40% RAP + 44% NA+ 4% CE+ 12% SD	150 mm X 150 mm X 150 mm	85	4.89
3.	25% RAP + 53% NA+ 6% CE+ 16% SD	150 mm X 150 mm X 150 mm	145	5.62

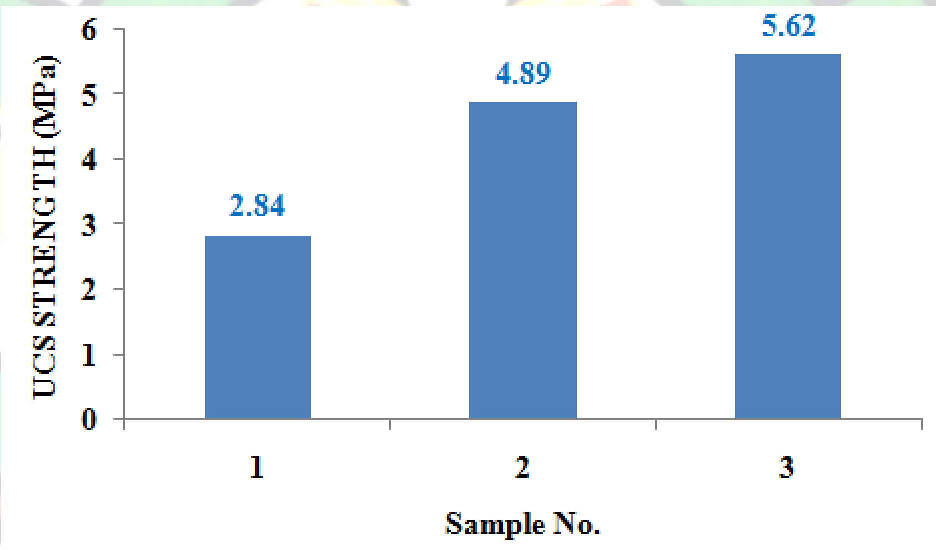

Figure 4. UCS after 7 days at Various Samples

Table 8 Determination of Cube Strength after 28 days

Sample No.	Samples	Cube Size (mm)	Maximum Load at Failure (kN)	UCS (MPa) 28 Days
1.	60% RAP + 30% NA+ 2% CE + 8% SD	150 mm X 150 mm X 150 mm	85	3.42
2.	40% RAP + 44% NA+ 4% CE+ 12% SD	150 mm X 150 mm X 150 mm	128	5.98
3.	25% RAP + 53% NA+ 6% CE+ 16% SD	150 mm X 150 mm X 150 mm	148	6.82

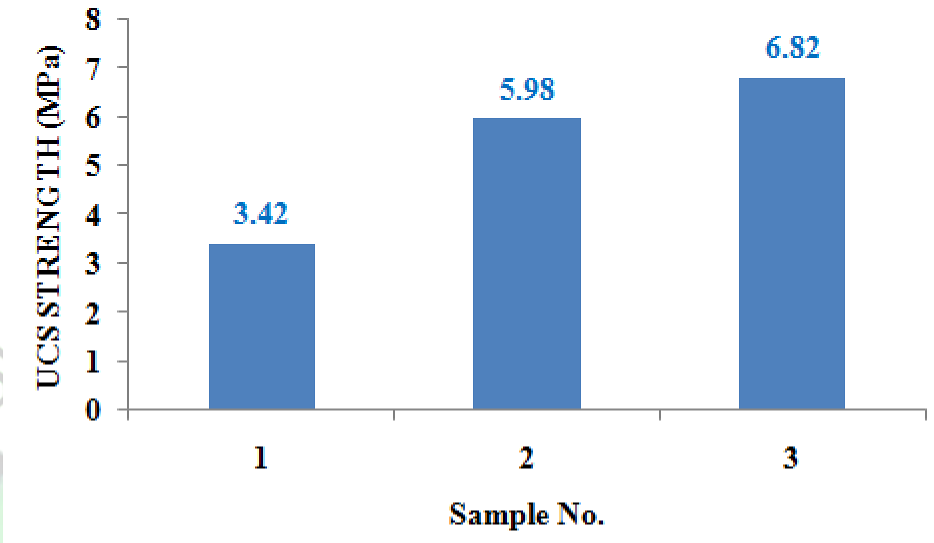

Figure 5. UCS after 28 days at Various Samples

Modified Proctor Test

Compaction represents one of the most important requirements related to compaction work, the most important of which are roads, earthen dams and foundations. Compaction is known as the mechanical energy that increases it by expelling the air between its particles. The purpose of the test is to find the maximum dry density and optimum moisture content of the sample after being affected by the compaction process according to the Proctor method. Also to determine the energy that exposes the sample to compaction in the laboratory so that it can be represented on nature by using various compaction tools and equipment. The pressure theory test is based on evaluating the water content and dry density relationship of the sample for a specific compression stress. The mechanical process of compaction by reducing the air pores in the soil mass is called compaction.The result of test indicated that the dry density value improved significantly. Resistance of aggregate to abrasive is considered to be one of the signs indicating the quality of aggregate and since recycled aggregate from asphalt mixture is basically the product of crushing crusher.

(a)

(b)

(c)

(d)

Figure 6. Modified Proctor Compaction Testing Process (a, b, c, and d)

Table 9 Moisture Content Determination of Sample

Sl.No.	Sample	Dry Density (gm/cc)	Water Added (%)
1.	60% RAP + 30% NA+ 2% CE + 8% SD	1.824	4
2.	40% RAP + 44% NA+ 4% CE+ 12% SD	2.342	5
3.	25% RAP + 53% NA+ 6% CE+ 16% SD	2.026	6

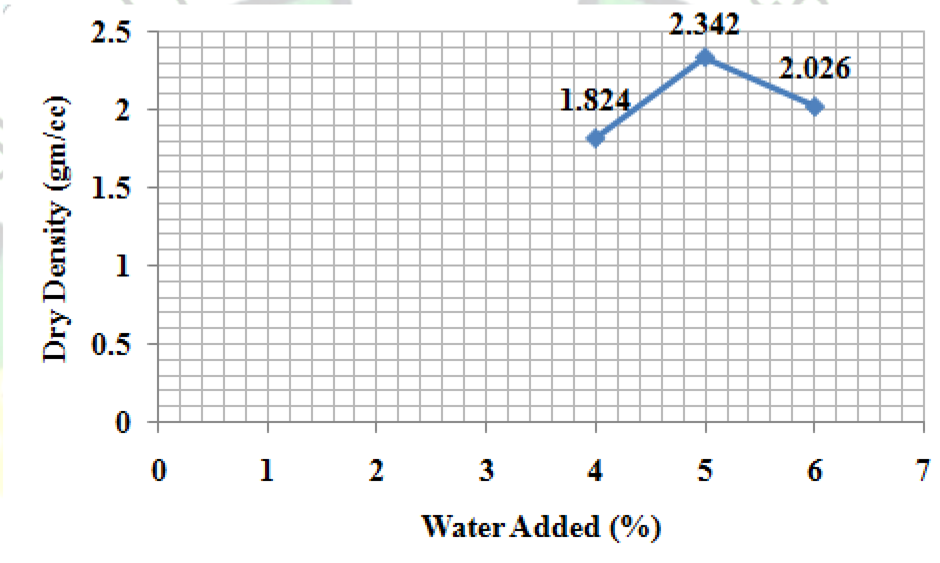

Figure 7. Compaction Curve of Samples

5. CONCLUSIONS

It was observed that RAP material in combination with natural aggregates in various proportions can be easily used in base courses of flexible pavements after mixing to match the required grading as per MORTH specifications. The unconfined compressive strengths increase as the percentage of cement increases. The improved properties of the samples containing recycled asphalt and cement percentages are evidence of the possibility of using these materials for asphalt roads.

1. The details of various MIX with the use of RAP and cement are shown in Tables 4 to 6, in which all the values of Table 4 to 6 for Requirement for WMM- grading (table 400-II) of MORTH revision 4 are satisfied.
2. The maximum dry density of the mix (2.342 g/cc) increased with 5% water content. Hence, this ratio is considered good for improving the density value of sample used in base course, this sample is best for WMM requirement.
3. By using 40% RAP and 44% Natural Aggregate 12% stone dust with 4% cement contents, 7 days UCS is 4.89 MPa which is more than 4.5 Mpa required as per MORTH specification, therefore this MIX can be used as a base course as flexible pavement.

REFERENCES

1. C. Rajesh Kumara, Renuka Sai Gadekaria, Dr. G.Vanib, Mini K Ma, Stabilization of black cotton soil and loam soil using reclaimed asphalt pavement and waste crushed glass, Science Direct, Materials Today: Proceedings 24 (2020) 379–387.
2. Sujit Kumar Pradhan, Gurukalyana Biswal, Utilization of reclaimed asphalt pavement (RAP) as granular sub-base material in road construction, Science Direct, Materials Today: Proceedings (2021).
3. Banafamu Andrew, Kasumba Andrew Buyondo, Hillary Kasedde, John B. Kirabira, Peter Wilberforce Olupot, Abdulfatah Abdu Yusuf, Investigation on the use of reclaimed asphalt pavement along with steel fibers in concrete, Science Direct, Case Studies in Construction Materials 17 (2022) e01356.
4. Kavitha Karthikeyan, Saravanan Kothandaraman, Goutham Sarang, Perspectives on the utilization of reclaimed asphalt pavement in concrete pavement construction , Science Direct, Case Studies in Construction Materials 19 (2023) e02242 A critical review
5. Danilo Lima, Jair Arrieta-Baldovino, Ronaldo L. S. Izzo, Sustainable Use of Recycled Asphalt Pavement in Soil Stabilization, Civil Engineering Journal Vol. 9, No. 09, September, 2023
6. Waseem Nazir, Alok Sharma, Comparative study of standard proctor and modified proctor test, 2021 JETIR May 2021, Volume 8, Issue 5.
7. Paul J. Cosentino, Albert M. Bleakley, Amir M. Sajjadi, and Andrew J. Petersen Evaluating Laboratory Compaction Techniques of Reclaimed Asphalt Pavement, Transportation Research Record: Journal of the Transportation Research Board.
8. Ahmed Mahmoud A. Mostafa, · Ahmed Gamal M. Morsi, Alnos Aly E. Hegazy, Using Reclaimed Asphalt Pavement in Backfilling Works Beneath the Structures, November 2024
9. Jirayut Suebsuk, Aniroot Suksan and Suksun Horpibulsuk, Strength Assessment of Cement Treated Soil reclaimed Asphalt Pavement (RAP) Mixture, Int. J. of GEOMATE, June, 2014.
10. Farag Khodary, The Effects of Adding Reclaimed Asphalt Pavement (Rap) and Cement on The Properties of Pavement Base Course, International Journal of Innovations in Engineering Research and Technology, Apr.-2021